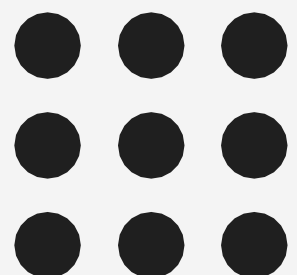# SNS COLLEGE OF ENGINEERING

Department of Information Technology

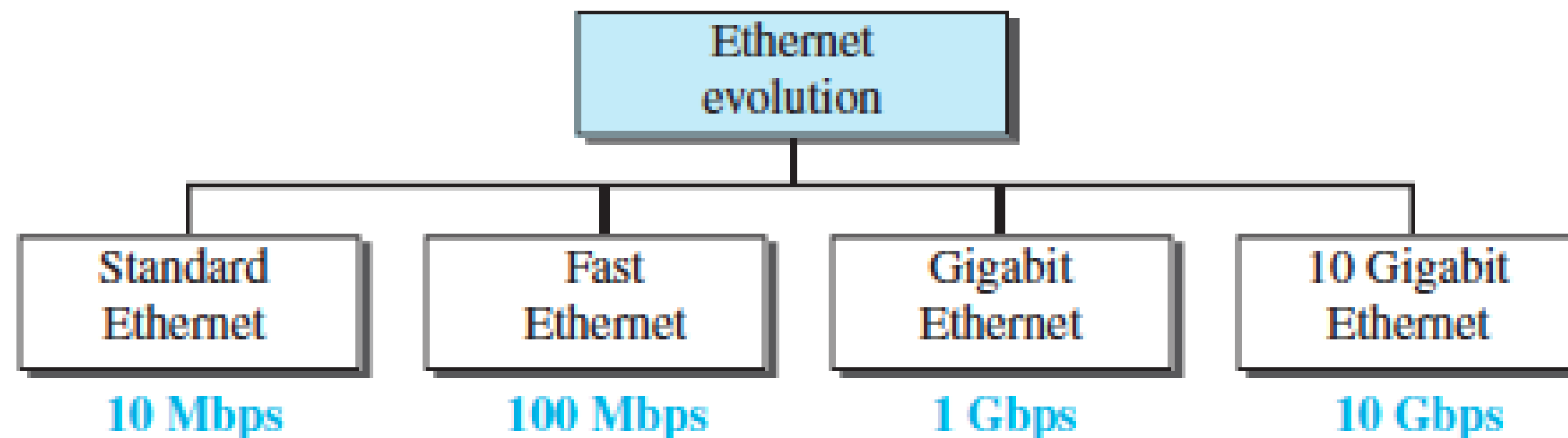## Course Name – 19IT401 Computer Networks

II Year / IV Semester

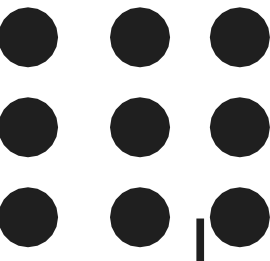## Unit 2 – Link Layer

Topic 7- Ethernet, 802.11

Wired LAN - Ethernet

- In the 1980s and 1990s several different types of LANs were used. All of these LANs used a media-access method to solve the problem of sharing the media.
- The Ethernet used the CSMA/CD approach. The Token Ring, Token Bus, and FDDI (Fiber Distribution Data Interface) used the token-passing approach.
- The Ethernet LAN was developed in the 1970s by **Robert Metcalfe and David Boggs**.
- Digital Equipment and Intel Corporation joined Xerox to define a 10-Mbps Ethernet standard in 1978. It then formed the basis for **IEEE standard 802.3**
- Since then, it has gone through four generations: Standard Ethernet (10 Mbps), Fast Ethernet (100 Mbps), Gigabit Ethernet (1 Gbps), and 10 Gigabit Ethernet (10 Gbps)
- Terabit Ethernet or TbE has also evolved recently with speed over 100 Gbps. 400 Gigabit Ethernet (400G, 400GbE) and 200 Gigabit Ethernet (200G, 200GbE).

```
                    ┌──────────────┐
                    │   Ethernet   │
                    │  evolution   │
                    └──────┬───────┘
        ┌──────────┬───────┴────────┬──────────────┐
  ┌──────────┐ ┌──────────┐  ┌──────────┐   ┌────────────┐
  │ Standard │ │   Fast   │  │ Gigabit  │   │ 10 Gigabit │
  │ Ethernet │ │ Ethernet │  │ Ethernet │   │  Ethernet  │
  └──────────┘ └──────────┘  └──────────┘   └────────────┘
   10 Mbps      100 Mbps       1 Gbps          10 Gbps
```
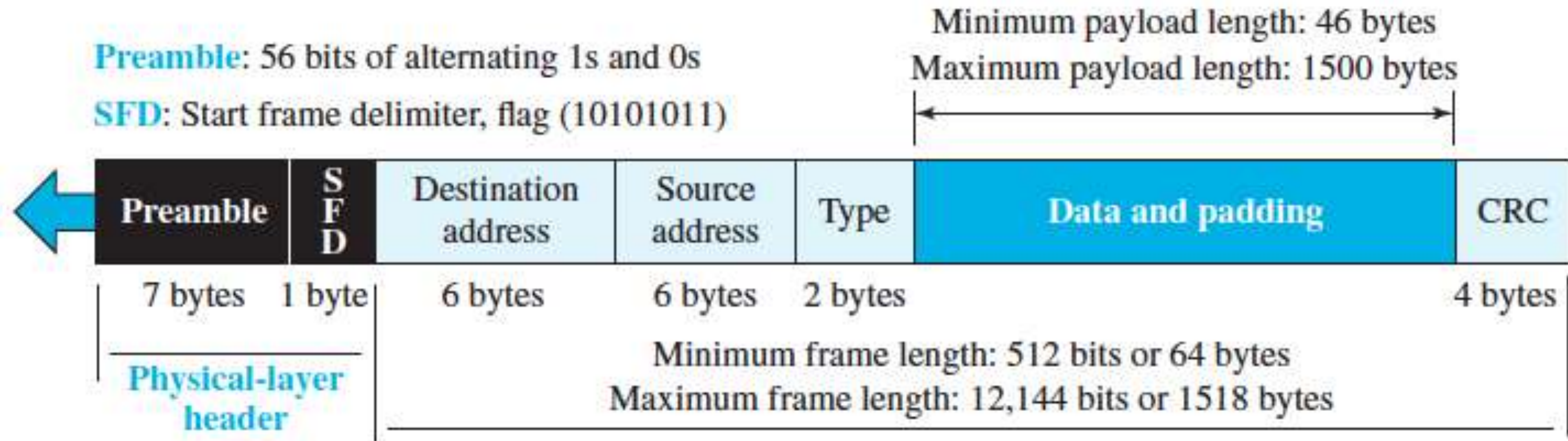
Characteristics of Ethernet

- Ethernet is limited to supporting a maximum of 1024 hosts.
- Ethernet has a total reach of only 2500 m (with the use of repeaters)
- Ethernets works best under lightly loaded conditions (less than 30%).
- Easy to administer and maintain
- Ethernet uses Manchester Encoding to transmit on physical links
- Connectionless and Unreliable
  - No connection establishment
  - Frames may be dropped or lost during transmission
  - No acknowledgement
 - Corrupted frame may be dropped silently

Wired LAN - Ethernet

Frame Format

Preamble: 56 bits of alternating 1s and 0s

SFD: Start frame delimiter, flag (10101011)

Minimum payload length: 46 bytes
Maximum payload length: 1500 bytes

Preamble	SFD	Destination address	Source address	Type	Data and padding	CRC
7 bytes	1 byte	6 bytes	6 bytes	2 bytes		4 bytes

Physical-layer header

Minimum frame length: 512 bits or 64 bytes
Maximum frame length: 12,144 bits or 1518 bytes

Frame Length
An Ethernet frame needs to have a minimum length of 512 bits or 64 bytes.
The maximum length of a frame (without preamble and SFD field) as 1518 bytes. If we subtract the 18 bytes of header and trailer, the maximum length of the payload is 1500 bytes.
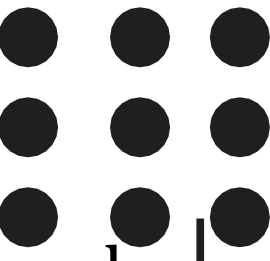
Wired LAN - Ethernet

Frame Format

- Preamble - This field contains 7 bytes (56 bits) alert the receiving system to the coming frame and enable it to synchronize its clock if it's out of synchronization.

- Start frame delimiter (SFD) - This field (1 byte: 10101011) signals the beginning of the frame.

- Destination address (DA) - This field is six bytes (48 bits) and contains the linklayer address of the destination station or stations to receive the packet.

- Source address (SA) - This field is also six bytes and contains the link-layer address of the sender of the packet.

- Type - This field defines the upper-layer protocol whose packet is encapsulated in the frame. This protocol can be IP, ARP, OSPF, and so on.

- Data - This field carries data encapsulated from the upper-layer protocols. It is a minimum of 46 and a maximum of 1500 bytes.

- CRC - The last field contains error detection information, in this case a CRC-32

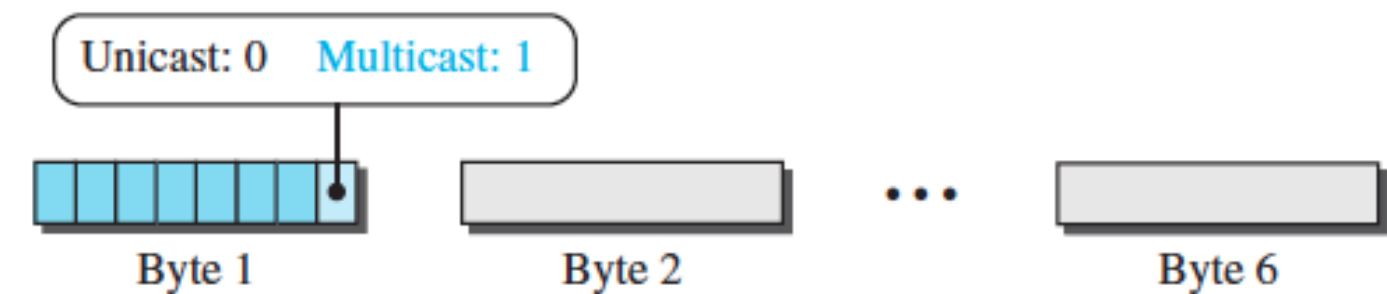# Wired LAN - Ethernet

Address Format

Each station on an Ethernet network has its own network interface card (NIC).

The Ethernet address is **6 bytes (48 bits)**, normally written in hexadecimal notation, with a colon between the bytes.

Ethernet MAC address - **4A:30:10:21:10:1A**

- Unicast - If the least significant bit of the first byte in a destination address is 0, the address is unicast;
- Multicast - If the least significant bit of the first byte in a destination address is 0, the address is multicast.
- Broadcast - A broadcast destination address is forty-eight 1s (All one's)

a. 4A:30:10:21:10:1A
b. 47:20:1B:2E:08:EE
c. FF:FF:FF:FF:FF:FF

Unicast: 0   Multicast: 1

Byte 1   Byte 2   Byte 6

Wired LAN - Ethernet

Implementation

The implementations of Standard Ethernet are 10Base5, 10Base2, 10Base-T & 10Base-F

Implementation	Medium	Medium Length	Encoding
10Base5	Thick coax	500 m	Manchester
10Base2	Thin coax	185 m	Manchester
10Base-T	2 UTP	100 m	Manchester
10Base-F	2 Fiber	2000 m	Manchester

10Base5: Thick Ethernet

- The first implementation is called 10Base5, thick Ethernet, or Thicknet.
- Thick Ethernet uses bus topology with an external transceiver connected via a tap to a thick coaxial cable.
- The transceiver is responsible for transmitting, receiving, and detecting collisions.
- Collision occurs only in the coaxial cable.
- The maximum length of the cable must not exceed 500m.
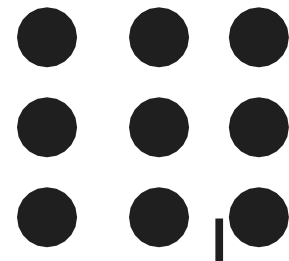
Wired LAN - Ethernet

10Base2: Thin Ethernet
- The second implementation is called 10Base2, thin Ethernet, or Cheapernet.
- 10Base2 also uses a bus topology, but the cable is much thinner and more flexible
- The transceiver is part of the network interface card (NIC).
- Thin coaxial cable is less expensive and easy installation than thick ethernet
- The length of each segment should not exceed 185m.

10Base-T: Twisted-Pair Ethernet
- The third implementation is called 10Base-T or twisted-pair Ethernet.
- 10Base-T uses a physical star topology. The stations are connected to a hub via two pairs of twisted cable
- The maximum length of the twisted cable is 100m
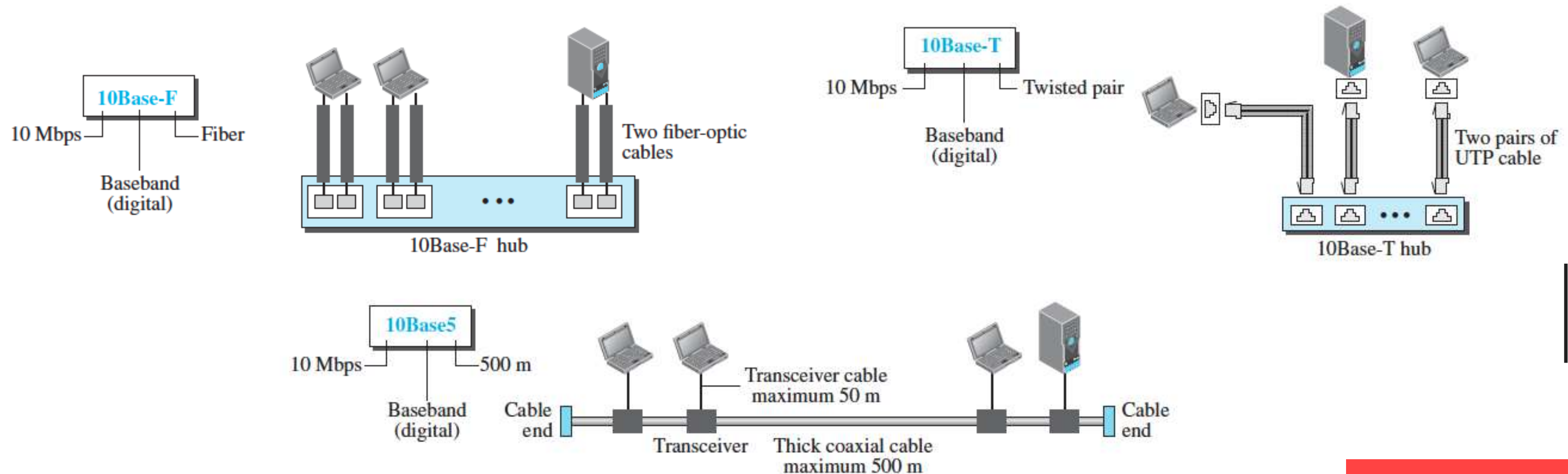- Any collision happens in the hub only.
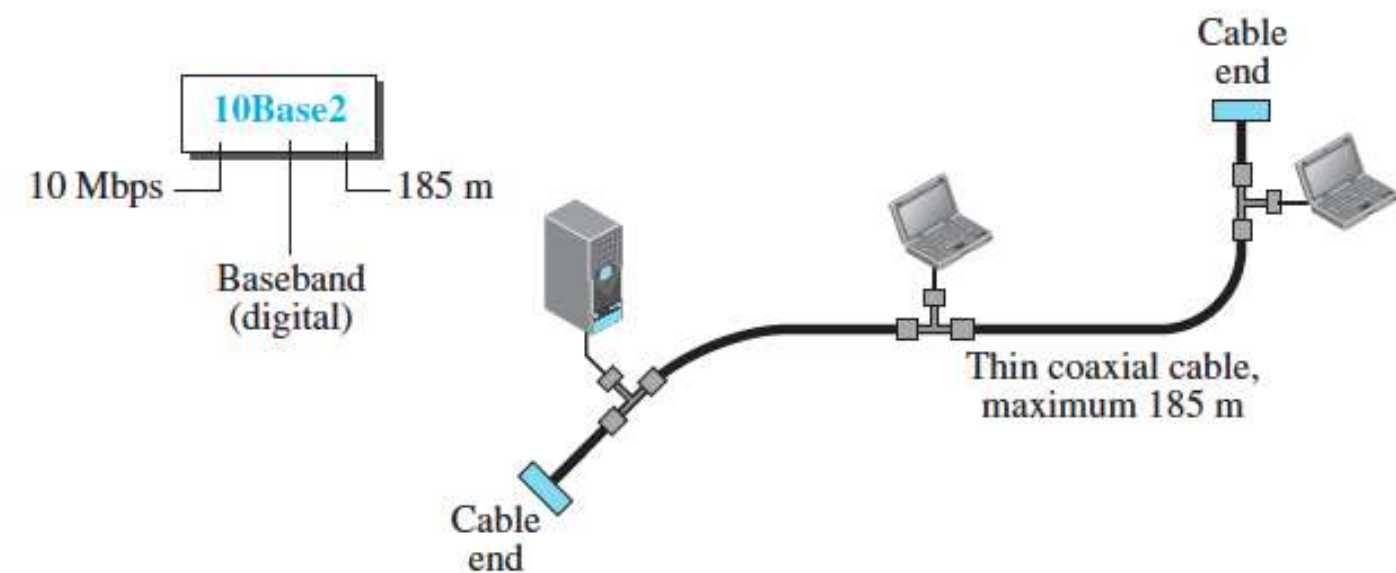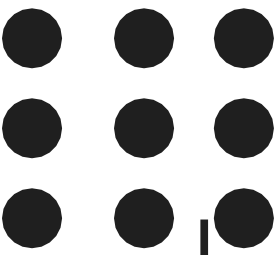
Wired LAN - Ethernet

10Base-F: Fiber Ethernet

- Although there are several types of optical fiber 10-Mbps Ethernet, the most common is called 10Base-F.
- 10Base-F uses a star topology to connect stations to a hub.
- The stations are connected to the hub using two fiber-optic cables.
- Maximum Length is 2000m

Wired LAN - Ethernet

Access Method

Ethernet follows Carrier Sense Multiple Access with Collision Detect (CSMA/CD)

Transmitter Algorithm

Ethernet is said to be a 1-persistent protocol. When the adaptor has a frame to send:
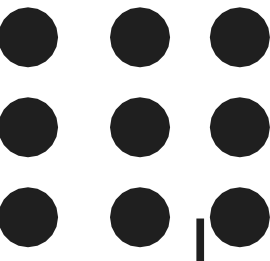
- If line is idle, it transmits the frame immediately.
- If line is busy, it waits for the line to go idle and then transmits immediately.

It is possible for two (or more) adaptors to begin transmitting at the same time.

- In such case, the frames collide
- They transmit a 32-bit jamming sequence and then stop the transmission.
- Retransmits after a back-off procedure

Wired LAN - Ethernet

FAST ETHERNET

In the 1990s, some LAN technologies with transmission rates higher than 10 Mbps, such as FDDI and Fiber Channel, appeared on the market.

Ethernet made a big jump by increasing the transmission rate to 100 Mbps, and the new generation was called the Fast Ethernet.

The goals of Fast Ethernet can be summarized as follows:
1. Upgrade the data rate to 100 Mbps.
2. Make it compatible with Standard Ethernet.
3. Keep the same 48-bit address.
4. Keep the same frame format

Access Method
- With CSMA/CD use a passive hub and star topology but make the maximum size of the network 250 meters.
- With link-layer switch with a buffer to store frames and a full-duplex connection to each host to make the transmission medium private for each host. In this case, there is no need for CSMA/CD

Wired LAN - Ethernet
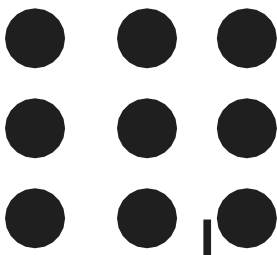
FAST ETHERNET

Autonegotiation   - New Feature

Autonegotiation allows two devices to negotiate the mode or data rate of operation.
It was designed particularly to allow incompatible devices to connect to one another.

Topology

Fast Ethernet is designed to connect two or more stations. If there are only two stations, they can be connected point-to-point. Three or more stations need to be connected in a star topology with a hub or a switch at the center.

Encoding and Cabling

Implementation	Medium	Medium Length	Wires	Encoding
100Base-TX	UTP or STP	100 m	2	4B5B + MLT-3
100Base-FX	Fiber	185 m	2	4B5B + NRZ-I
100Base-T4	UTP	100 m	4	Two 8B/6T

GIGABIT ETHERNET

The need for an even higher data rate resulted in the design of the Gigabit Ethernet Protocol (1000 Mbps).

The IEEE committee calls it the **Standard 802.3z**.

The goals of the Gigabit Ethernet were to upgrade the data rate to 1 Gbps, but keep the address length, the frame format, and the maximum and minimum frame length the same. The goals of the Gigabit Ethernet design can be summarized as follows:
1. Upgrade the data rate to 1 Gbps.
2. Make it compatible with Standard or Fast Ethernet.
3. Use the same 48-bit address.
4. Use the same frame format.
5. Keep the same minimum and maximum frame lengths.
6. Support autonegotiation as defined in Fast Ethernet.

GIGABIT ETHERNET

MAC Sublayer

- A main consideration in the evolution of Ethernet was to keep the MAC sublayer untouched. However, to achieve a data rate of 1 Gbps, this was no longer possible.

- Gigabit Ethernet has two distinctive approaches for medium access: half-duplex and fullduplex.

- Almost all implementations of Gigabit Ethernet follow the full-duplex approach, so we mostly ignore the half-duplex mode

- In the full-duplex mode of Gigabit Ethernet, there is no collision; the maximum length of the cable is determined by the signal attenuation in the cable.

- In full-duplex mode, there is a central switch connected to all computers or other switches. In this mode, for each input port, each switch has buffers in which data are stored until they are transmitted

- This means that CSMA/CD is not used.

GIGABIT ETHERNET
Topology
Gigabit Ethernet is designed to connect two or more stations. If there are only two stations, they can be connected point-to-point. Three or more stations need to be connected in a star topology with a hub or a switch at the center.

Implementation and Encoding

Implementation	Medium	Medium Length	Wires	Encoding
1000Base-SX	Fiber S-W	550 m	2	8B/10B + NRZ
1000Base-LX	Fiber L-W	5000 m	2	8B/10B + NRZ
1000Base-CX	STP	25 m	2	8B/10B + NRZ
1000Base-T4	UTP	100 m	4	4D-PAM5

Wired LAN - Ethernet

10 GIGABIT ETHERNET

The IEEE committee created 10 Gigabit Ethernet and called it IEEE **Standard 802.3ae**.

The goals of the 10 Gigabit Ethernet design can be summarized as upgrading the data rate to 10 Gbps, keeping the same frame size and format, and allowing the interconnection of LANs, MANs, and WAN possible.

This data rate is possible only with fiber-optic technology at this time. The standard defines two types of physical layers: LAN PHY and WAN PHY.

The first is designed to support existing LANs; the second actually defines a WAN with links connected through SONET OC-192.

10 GIGABIT ETHERNET

Implementation

10 Gigabit Ethernet operates only in full-duplex mode, which means there is no need for contention; CSMA/CD is not used in 10 Gigabit Ethernet.

Four implementations are the most common: 10GBase-SR, 10GBase-LR, 10GBase-EW, and 10GBase-X4.

Implementation	Medium	Medium Length	Number of wires	Encoding
10GBase-SR	Fiber 850 nm	300 m	2	64B66B
10GBase-LR	Fiber 1310 nm	10 Km	2	64B66B
10GBase-EW	Fiber 1350 nm	40 Km	2	SONET
10GBase-X4	Fiber 1310 nm	300 m to 10 Km	2	8B10B